# IEEE 802.11 (WLAN)

## Other WGs and WLAN Implementation issues

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# IEEE 802.11 WGs

| Gruppi di standardizzazione IEEE 802.11 | Descrizione |
|---|---|
| IEEE 802.11 | lo standard originale: bitrate da 1 a 2 Mbps, spettro 2.4 Ghz, livello fisico sia radio che infrarosso |
| IEEE 802.11a | 54 Mbit/s, 5 GHz, lanciato nel 2001 |
| IEEE 802.11b | sviluppo di IEEE 802.11 (1999), da 5.5 a 11 Mbps |
| IEEE 802.11d | estensioni per roaming internazionale |
| IEEE 802.11e | estensioni per **qualità del servizio** |
| IEEE 802.11f | standard per **Inter Access Point Protocol (IAPP)** |
| IEEE 802.11g | 54 Mbit/s, 2.4 GHz, retrocompatibile con IEEE 802.11b |
| IEEE 802.11h | selezione dinamica dei canali e controllo della potenza trasmissiva (compatibile con direttive europee) |
| IEEE 802.11i | integrazioni e estensioni per la **sicurezza** (2004) |
| IEEE 802.11j | estensioni per direttive giapponesi |
| IEEE 802.11k | estensioni per misurazione dei parametri radio |
| IEEE 802.11n | estensioni per throughput elevati (oltre 200 Mbps) mediante tecnologia **MIMO** (trasmettitori e ricevitori multipli) |
| IEEE 802.11p | accesso wireless per **sistemi veicolari** (WAVE) |
| IEEE 802.11r | estensioni per roaming veloce |
| IEEE 802.11s | estensioni per reti wireless mesh |
| IEEE 802.11t | metodi e metriche per misurazione e predizione delle prestazioni |
| IEEE 802.11u | internetworking con reti non 802.11 (cellulari) |
| IEEE 802.11v | gestione e amministrazione delle reti wireless |

# WLAN and WMAN Wireless Standards and technologies

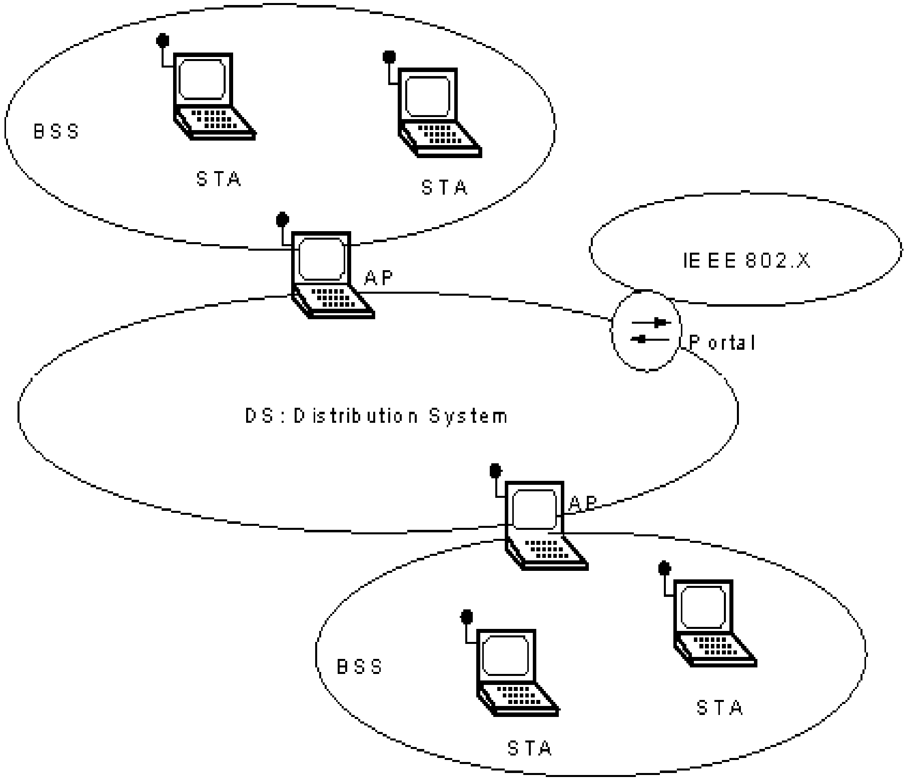
| | UWB | Bluetooth | Wi-fi | Wi-fi | Wi-fi | WiMAX | WiMAX | EDGE | CDMA | UMTS |
|---|---|---|---|---|---|---|---|---|---|---|
| Standard | 802.15.3a | 802.15.1 | 802.11a | 802.11b | 802.11g | 802.16d | 802.16e | 2,5G | 3G | 3G |
| contesto | WPAN | WPAN | WLAN | WLAN | WLAN | WMAN (fisso) | WMAN (mobile) | WWAN | WWAN | WWAN |
| MAX bitrate | 110-480 Mbps | 720 Kbps | 54 Mbps | 11-22 Mbps | 54-108 Mpbs | 75 Mbps (20 Mhz) | 30 Mbps (10 Mhz) | 384 Kbps | 2,4 Mbps | 10 Mbps |
| distanza | 10 m | 10 m | 100 m | 100 m | 100 m | 10 km | 5 km | 5 km | 5 km | 5 km |
| spettro | 7,5 Ghz | 2,4 Ghz (ISM) | 5 Ghz | 2,4 Ghz (ISM) | 2,4 Ghz (ISM) | 11 Ghz | 2-6 Ghz | 1800 Mhz | multi | multi |

# Service Sets

- **Basic Service Set**
  - Access Point
  - Client nodes
  - Service Set Identifier (SSID): 32 char ID (network name?)
    - not a password: can be sniffed (in clear in packet headers)
    - Used for association of clients to APs (sharing the same SSID)
- **Extended service set**
  - two or more BSS connected by distribution system
    - Wireless routers (different SSID)
    - Wireless repeaters (same SSID)?
- **Independent Basic Service Set (IBSS)**
  - Ad hoc network (peer to peer nodes, no AP authentication)

# Range Extension between BSS cells and DS

## IEEE 802.11: Distribution System (DS)



**AP**: Access Point
**BSS**: Basic Service Set
**ESS**: Extended Service Set
**DS**: Network to transmit packets between BSSs to realize ESSs.

# SSID

- **Service Set Identifier (SSID):**
  - not a password! can be sniffed
    - AirMagnet, Netstumbler, AiroPeek NX...
    - Windows Xp sniffs SSID to configure NIC devices for access
      - ...potential for attacks?
  - Admin: useless to delete SSID info from Beacon frames...
    - ...Because SSID is used for association of clients to APs
  - Many SSID are factory-defined and never changed
    - E.g. CISCO “tsunami”, Proxim “Proxim”, Symbol “Symbol”

# BSS attacks

- **BSS Attacks:**
  - (Phy/MAC) layer interference (bla bla bla bla...)
  - (MAC) CTS flooding
- **Rogue access points**
  - Un-authorized access point with no security alignment
  - Man in the middle + rogue access point to re-associate the client
    - Sniff area with NetStumbler, AirMagnet WLAN analyzer
    - Use centralized applications: AirWave, CiscoWorks
    - Use TCP port scanner (SuperScan 3.0) to monitor all 80 ports (rogue AP Web server responds?)

# BSS security assessment (1)

- Review existing security policies, and monitor for rogue access points
  - Activate WEP at the very least
    - WEP key is static and crackable with AirSnort, WEPcrack
- Utilize pre-shared key, or dynamic key exchange mechanisms, and static IP (no DHCP)
    - IEEE 802.11i, Advanced Encryption Standard (AES) and dynamic key exchange (Wireless Protected Access, Wi-Fi Protected Access, WPA)
    - DHCP gives local IP and enable crackers for IP access to the whole network
- Ensure NIC and access point firmware is up-to-date
- Ensure only authorized people can reset the access points
  - Disable reset buttons and console programming port

# BSS security assessment (2)

- Assign "strong" passwords to access points, locate in good places and and disable them when not used
- Disable SSID broadcast in Beacons (but still present in association frames)
- Adopt Access Controller over Open Network (not authenticated access) Access Points
  - Implement mutual authentication mechanisms
  - Authentication of clients performed with RADIUS servers, IEEE 802.1X
- Use firewalls and IPSec VPNs technologies over client devices

# IEEE 802.11 AP configuration (1)

- **Configuring the AP...**
    - Direct cable connection (console)
    - Wireless Web server access to URL “http:/192.168.0.x”
    - do it before installation of multiple APs
- Set the IP address (static?)
- Set the radio channel
    - 1,6,11 preferable for IEEE 802.11b

# IEEE 802.11 AP configuration (2)

- **...Configuring the AP**
  - Set transmission power (max 100 mw)
  - Set SSID identifier (network name?)
  - Set allowed data rates
  - Set beacon repetition interval (typical 10 ms)
  - Set RTS/CTS activation and payload threshold
  - Set fragmentation threshold
  - Set WEP encryption (>128 bit = 26 HEX char)
  - Set mutual devices authentication (no open system):
    - Pre-shared keys, 802.1x + RADIUS authentication server, WPA
  - Set admin AP interface passwords

# IEEE 802.11 WLAN deployment

- **Radio planning**
  - Map areas and channels with coverage analysis (AirMagnet, Yellow Jacket)
  - Check pre-existing radio channels assigned (neighbor network?)
    - 75% are channel 6 (device default) (use NetStumbler)
  - Put AP high on the ceiling, with antennas vertical towards the floor (better propagation and coverage area)
    - Beware of metallic grids within walls (Faraday's grids)
  - Use Power over Ethernet (PoE) if the plug is unpractical
- **Configuring the wireless repeater (increase AP radio range)**
  - Switch the AP to repeater mode (see next slides)
  - Set the SSID of the same root AP
  - Set the preferred AP and secondary AP to forward frames to
  - Clients associates with the strongest signal with the same SSID

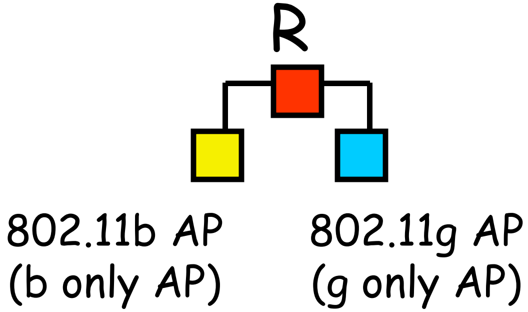
# IEEE 802.11 WLAN deployment

- **Configuring the wireless bridge (connects two or more wireless networks by considering MAC addresses only)**
  - **AP** are similar to bridges, but connect many wireless users devices (NICs) to one network (e.g. Ethernet) and forward all frames received (no filtering)
  - **Workgroup Bridges**. Workgroup bridges connect wireless networks to larger, wired Ethernet networks

- **Configuring the wireless router (connects wireless clients to more than one network, and always consider IP addresses)**
  - Setup IP address and domain name server (DNS) address, or DHCP server
  - Setup SSID, RTS/CTS, WEP, frequency channel, fragmentation, power, etc.
  - Allow wireless clients to connect to more than one wireless network in the area
  - Implement Network Address Translation (NAT) for IP address sharing
  - Improve network management options and network performance (selective forwarding, no broadcast)
  - Improve security with built-in firewalls (IP filtering), IPSec and VPN support

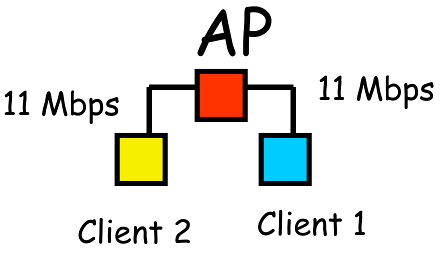
# Cohexistence Problems: mixed mode clients b/g

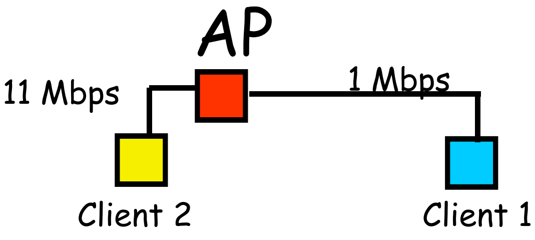
- **IEEE 802.11b and IEEE 802.11g technologies**
  - 802.11b is DSSS (11 Mb/s) in 2.4 Ghz
    - Mbps depend on the distance from AP
  - 802.11g is DSSS (54 Mb/s) in 2.4 Ghz (extra speed)
    - New technology to deploy over 802.11b systems?
    - Mixed mode Wireless router with b/g access support?
    - Performance drawbacks
    - Low throughput (waiting the slowest technology for channel access)... Similar to the "slow car on the tunnel" problem
  - Solution: separate b and g communication with different APs connected to the network router
  - Non-overlapping channels 1, 6, 11
  - Use mixed mode protection (RTS/CTS or CTS-to-self)



# Cohexistence Problems: mixed mode clients b/g

- **E.g. homogeneous IEEE 802.11b (or IEEE 802.11g) technology**
  - BSS Scenario 1: 802.11 AP streaming large files to two clients
    - Clients near to AP (both at 11 Mbps download speed)
    - One client moves far from AP (1 Mbps)
  - Results in low speed for both clients!!! (-77% = avg 7.2 to 1.6 Mbps)





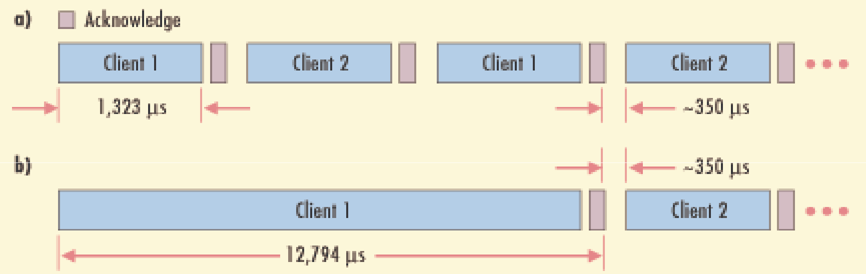
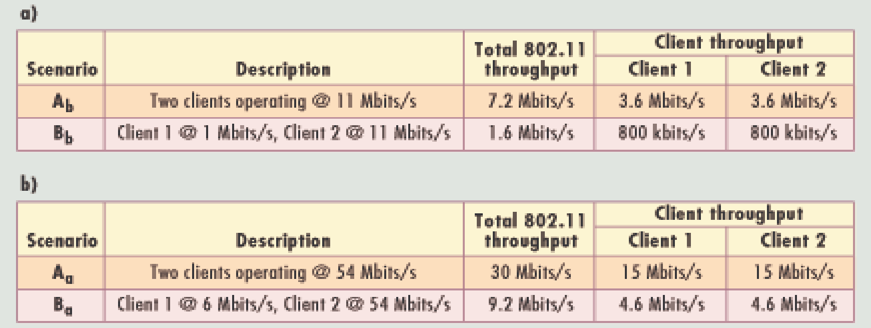


Fig.1 When two clients are close to an AP (a), the data rates are similar. But, as Client 1 roams to the network edge (b), its rate drops quickly, slowing considerably the time taken for the packet transmit and ACK.



a)

| Scenario | Description | Total 802.11 throughput | Client throughput | |
|---|---|---|---|---|
| | | | Client 1 | Client 2 |
| $A_b$ | Two clients operating @ 11 Mbits/s | 7.2 Mbits/s | 3.6 Mbits/s | 3.6 Mbits/s |
| $B_b$ | Client 1 @ 1 Mbits/s, Client 2 @ 11 Mbits/s | 1.6 Mbits/s | 800 kbits/s | 800 kbits/s |

b)

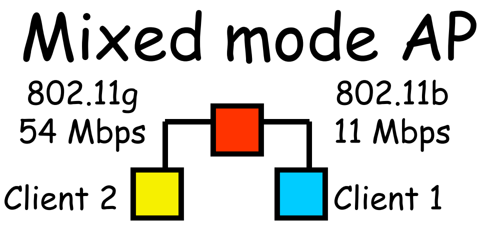
| Scenario | Description | Total 802.11 throughput | Client throughput | |
|---|---|---|---|---|
| | | | Client 1 | Client 2 |
| $A_a$ | Two clients operating @ 54 Mbits/s | 30 Mbits/s | 15 Mbits/s | 15 Mbits/s |
| $B_a$ | Client 1 @ 6 Mbits/s, Client 2 @ 54 Mbits/s | 9.2 Mbits/s | 4.6 Mbits/s | 4.6 Mbits/s |

Fig.2 The effect of a roaming client is similar for both 802.11b (a) and 802.11a (b) networks. The AP will alternate transmissions between Client 1 and Client 2, and network throughput will drop between 70 and 77 percent.

Figure credits: http://www.commsdesign.com

# Cohexistence Problems: mixed mode clients b/g

- **E.g. mixed IEEE 802.11g IEEE 802.11b technology**
  - BSS Scenario 2: 802.11b/g AP streaming large files to two clients
    - A) two IEEE 802.11g clients (both at 54 Mbps download speed, 30 Mbps avg MAC through.)
    - B) one client IEEE 802.11g and one client IEEE 802.11b (802.11b cannot detect OFDM transmissions, and need CTS with IEEE 802.11b modulation scheme)
      = - 64% , avg 11.2 Mbps
    - Partial solution: initial contention window size: TXOP every 16 slots (g) and every 32 slots (b)



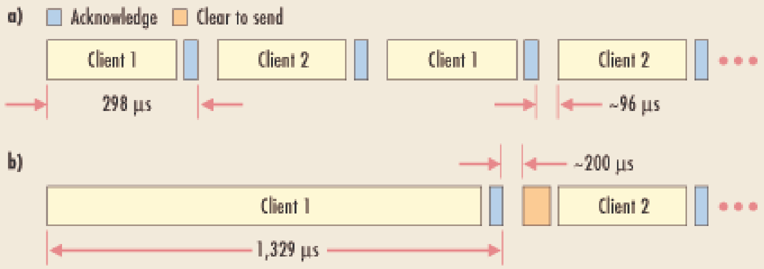
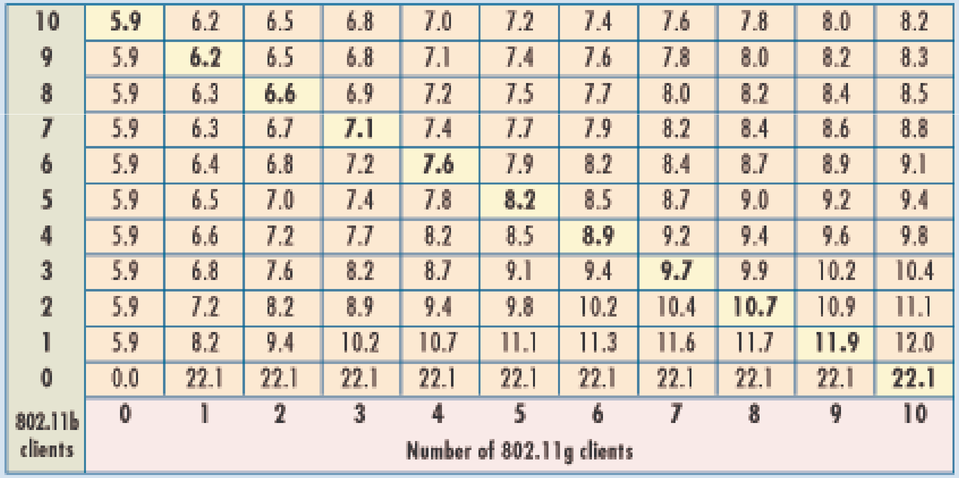


Fig.3 IEEE 802.11g-only networks (a) can hit 30-Mbit/s throughput. But, when a legacy 802.11b client is introduced (b), protection mechanisms kick in but network throughput still drops to 9.3 Mbits/s (including TCP/IP).



| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 | 5.9 | 6.2 | 6.5 | 6.8 | 7.0 | 7.2 | 7.4 | 7.6 | 7.8 | 8.0 | 8.2 |
| 9 | 5.9 | 6.2 | 6.5 | 6.8 | 7.1 | 7.4 | 7.6 | 7.8 | 8.0 | 8.2 | 8.3 |
| 8 | 5.9 | 6.3 | 6.6 | 6.9 | 7.2 | 7.5 | 7.7 | 8.0 | 8.2 | 8.4 | 8.5 |
| 7 | 5.9 | 6.3 | 6.7 | 7.1 | 7.4 | 7.7 | 7.9 | 8.2 | 8.4 | 8.6 | 8.8 |
| 6 | 5.9 | 6.4 | 6.8 | 7.2 | 7.6 | 7.9 | 8.2 | 8.4 | 8.7 | 8.9 | 9.1 |
| 5 | 5.9 | 6.5 | 7.0 | 7.4 | 7.8 | 8.2 | 8.5 | 8.7 | 9.0 | 9.2 | 9.4 |
| 4 | 5.9 | 6.6 | 7.2 | 7.7 | 8.2 | 8.5 | 8.9 | 9.2 | 9.4 | 9.6 | 9.8 |
| 3 | 5.9 | 6.8 | 7.6 | 8.2 | 8.7 | 9.1 | 9.4 | 9.7 | 9.9 | 10.2 | 10.4 |
| 2 | 5.9 | 7.2 | 8.2 | 8.9 | 9.4 | 9.8 | 10.2 | 10.4 | 10.7 | 10.9 | 11.1 |
| 1 | 5.9 | 8.2 | 9.4 | 10.2 | 10.7 | 11.1 | 11.3 | 11.6 | 11.7 | 11.9 | 12.0 |
| 0 | 0.0 | 22.1 | 22.1 | 22.1 | 22.1 | 22.1 | 22.1 | 22.1 | 22.1 | 22.1 | 22.1 |
| 802.11b clients | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | Number of 802.11g clients | | | | | | | | | | |

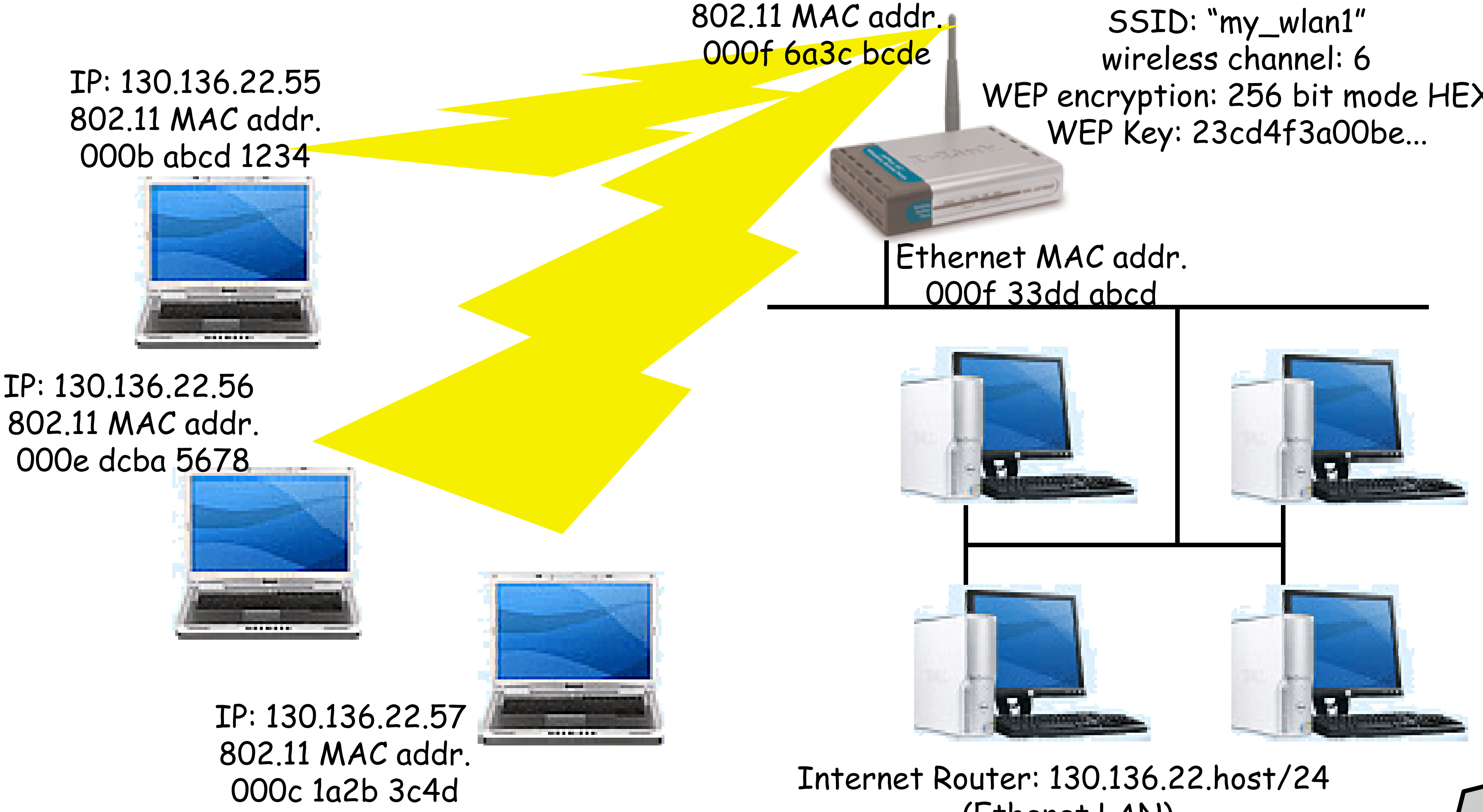
Fig.4 In a mixed 802.11g and 802.11b environment, the throughput (including TCP/IP overhead) depends on the number and type of clients associated with the AP. The figures represent total network throughput.

Figure credits: http://www.commsdesign.com

MenzoWentink, Tim Godfrey and Jim Zyren
Overcoming IEEE 802.11g's Interoperability Hurdles
COMMUNICATION SYSTEMS DESIGN, May 2003

# Configuration of a Wireless Network

- **Access Point mode (target config)**



Operating Mode: Access Point
IP: 130.136.22.50
Netmask: 255.255.255.0
SSID: “my_wlan1”
wireless channel: 6
WEP encryption: 256 bit mode HEX
WEP Key: 23cd4f3a00be...

802.11 MAC addr.
000f 6a3c bcde

IP: 130.136.22.55
802.11 MAC addr.
000b abcd 1234

Ethernet MAC addr.
000f 33dd abcd

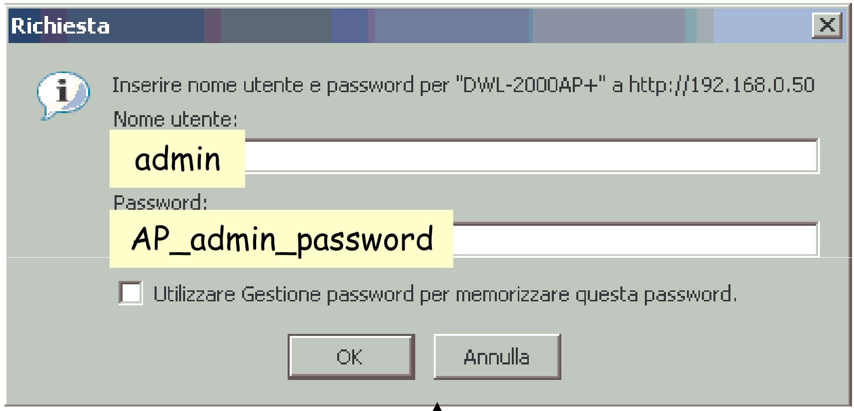
IP: 130.136.22.56
802.11 MAC addr.
000e dcba 5678

IP: 130.136.22.57
802.11 MAC addr.
000c 1a2b 3c4d

Internet Router: 130.136.22.host/24
(Ethenet LAN)

# Configuration of a Wireless Network

- **Access Point mode: step 0**
  **connect AP and set config PC**



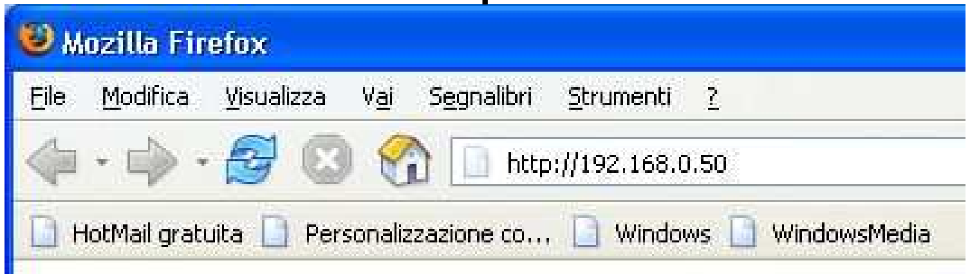
Richiesta

Inserire nome utente e password per "DWL-2000AP+" a http://192.168.0.50

Nome utente: admin

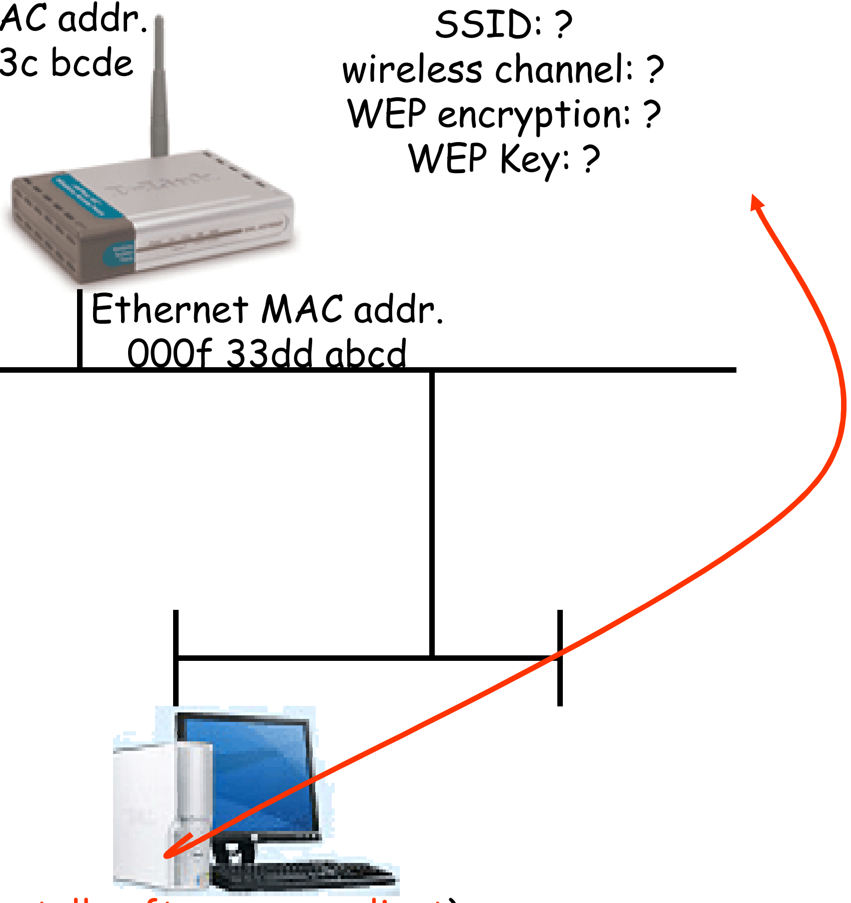
Password: AP_admin_password

☐ Utilizzare Gestione password per memorizzare questa password.



Mozilla Firefox

http://192.168.0.50



802.11 MAC addr.
000f 6a3c bcde

Operating Mode: ?
IP: 192.168.0.50 (default)
Netmask: 255.255.255.0 (default)
SSID: ?
wireless channel: ?
WEP encryption: ?
WEP Key: ?

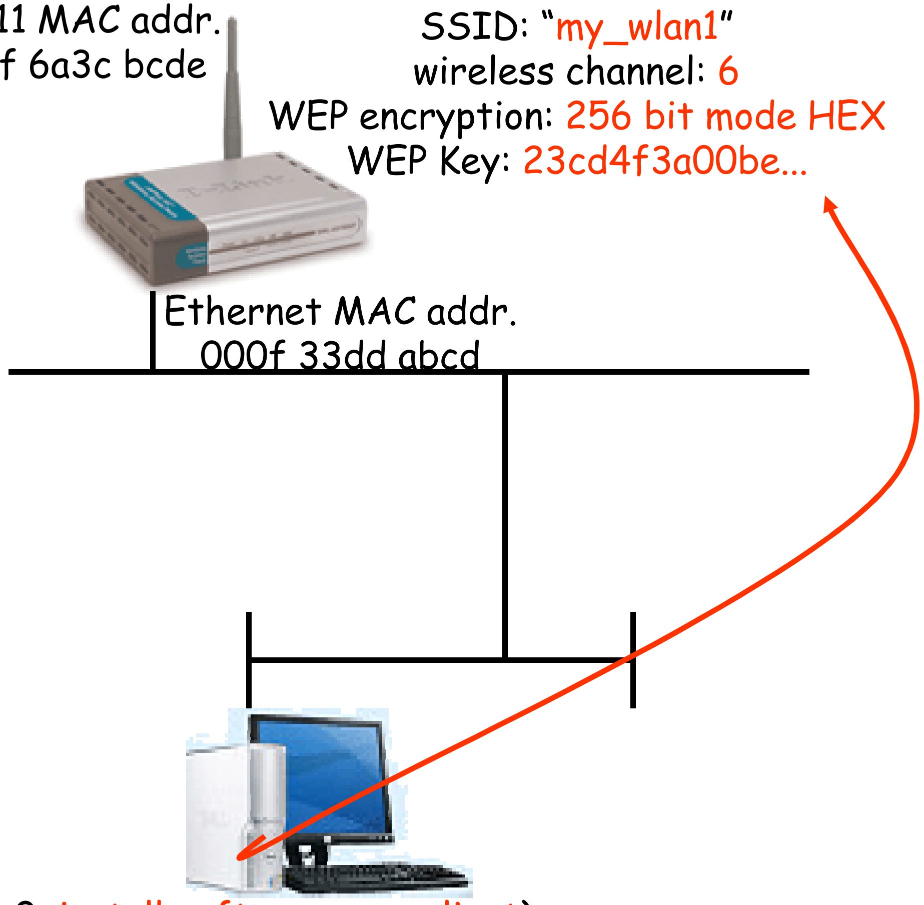
Ethernet MAC addr.
000f 33dd abcd

PC for AP config (step 0: install software, run client)
Via LAN Network: IP: 192.168.0.51, netmask: 255.255.255.0
Via console: attach serial cable, run client software

# Configuration of a Wireless Network

- **Access Point mode: step 1**
  **set LAN IP and config. parameters**

Operating Mode: Access Point
IP: 130.136.22.50
Netmask: 255.255.255.0
SSID: "my_wlan1"
wireless channel: 6
WEP encryption: 256 bit mode HEX
WEP Key: 23cd4f3a00be...



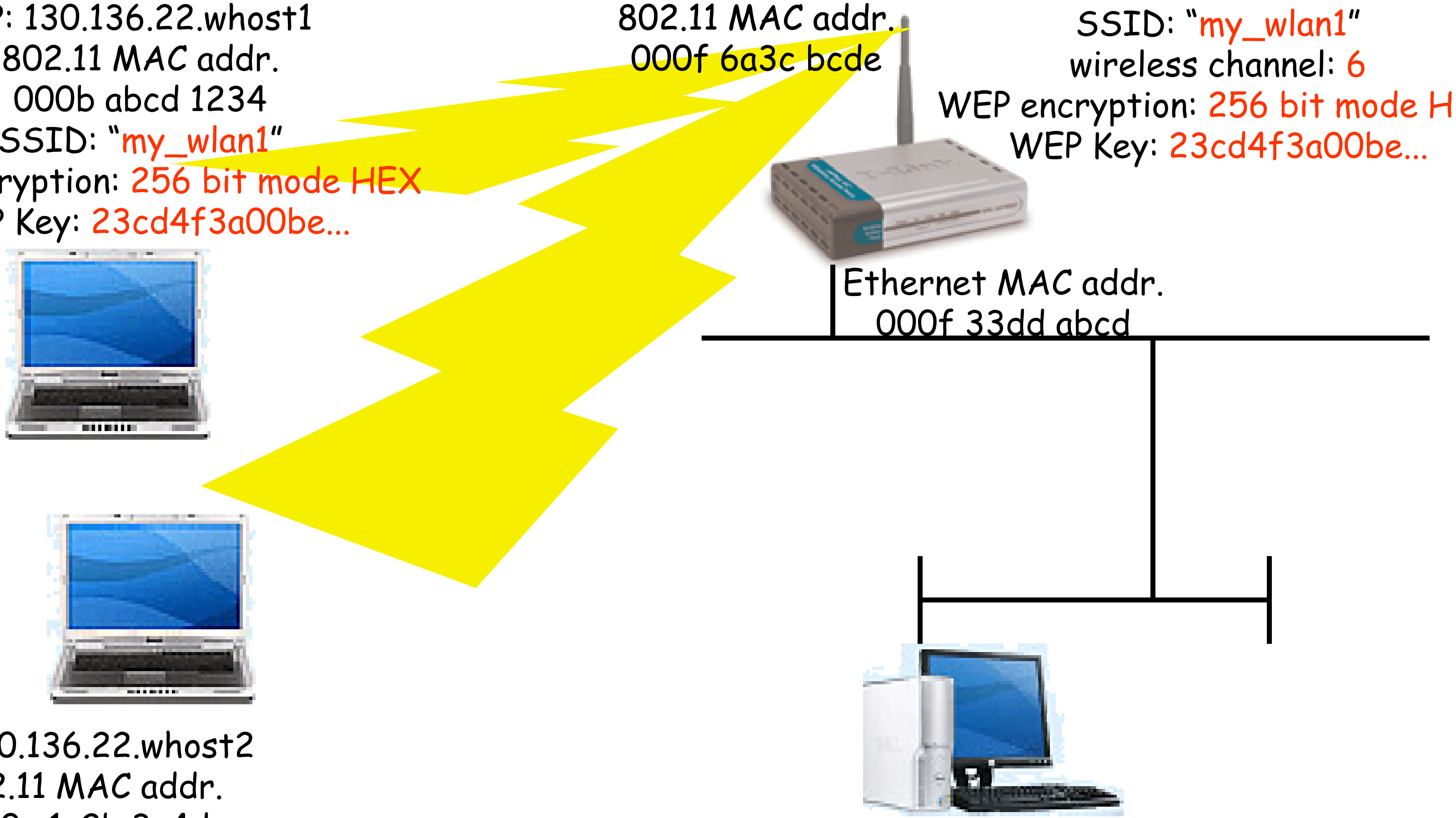
802.11 MAC addr.
000f 6a3c bcde

Ethernet MAC addr.
000f 33dd abcd

PC for AP config (step 0: install software, run client)
Via LAN Network: IP: 130.136.22.host, netmask: 255.255.255.0
Via console: attach serial cable to AP

# Configuration of a Wireless Network

- **Access Point mode: step 2**
  **set WLAN client parameters**



IP: 130.136.22.whost1
802.11 MAC addr.
000b abcd 1234
SSID: "my_wlan1"
WEP encryption: 256 bit mode HEX
WEP Key: 23cd4f3a00be...

802.11 MAC addr.
000f 6a3c bcde

Operating Mode: Access Point
IP: 130.136.22.50
Netmask: 255.255.255.0
SSID: "my_wlan1"
wireless channel: 6
WEP encryption: 256 bit mode HEX
WEP Key: 23cd4f3a00be...

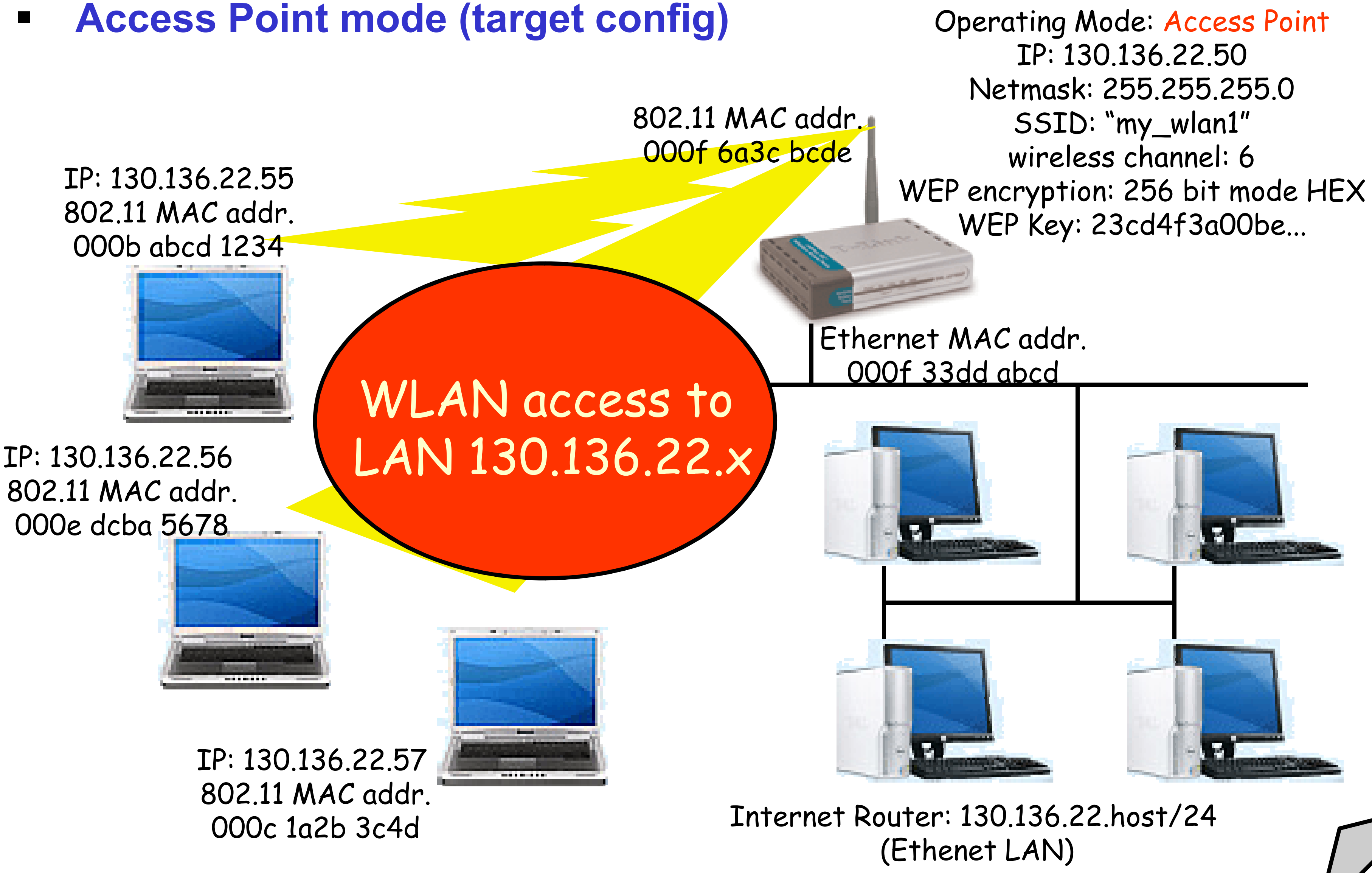
Ethernet MAC addr.
000f 33dd abcd

IP: 130.136.22.whost2
802.11 MAC addr.
000c 1a2b 3c4d
....

IP: 130.136.22.host,
netmask: 255.255.255.0

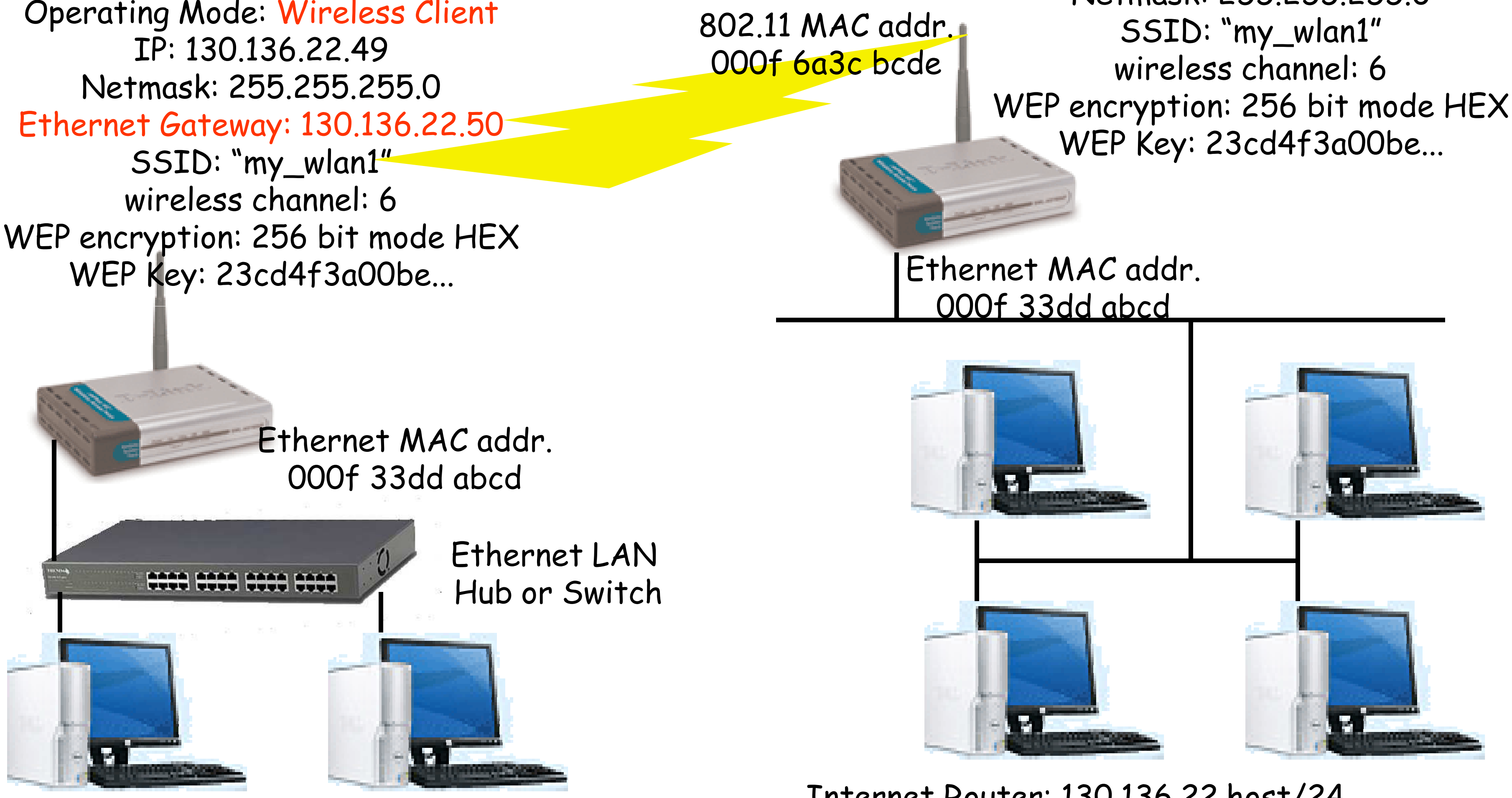
# Configuration of a Wireless Network

- Access Point mode (target config)



# Configuration of a Wireless Network

- **Other AP operating modes: Wireless client**



Operating Mode: Access Point
IP: 130.136.22.50
Netmask: 255.255.255.0
SSID: “my_wlan1”
wireless channel: 6
WEP encryption: 256 bit mode HEX
WEP Key: 23cd4f3a00be...

802.11 MAC addr.
000f 6a3c bcde

Operating Mode: Wireless Client
IP: 130.136.22.49
Netmask: 255.255.255.0
Ethernet Gateway: 130.136.22.50
SSID: “my_wlan1”
wireless channel: 6
WEP encryption: 256 bit mode HEX
WEP Key: 23cd4f3a00be...

Ethernet MAC addr.
000f 33dd abcd

Ethernet MAC addr.
000f 33dd abcd

Ethernet LAN
Hub or Switch

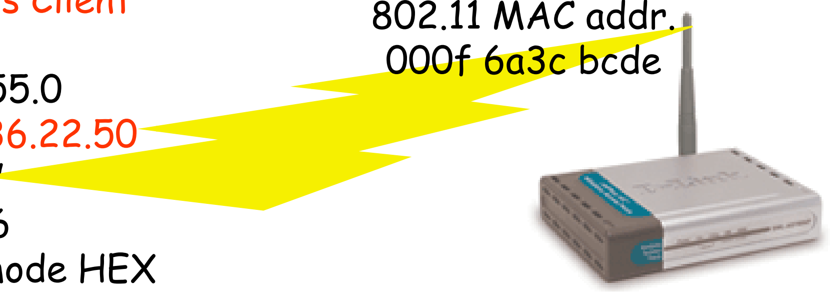
130.136.22.host/24

Internet Router: 130.136.22.host/24
(Ethenet LAN)

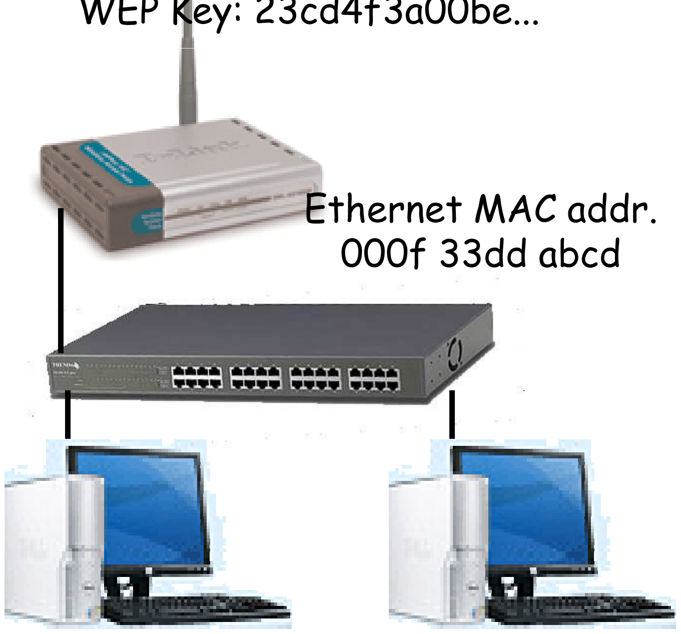
# Configuration of a Wireless Network

- **Other AP operating modes: Wireless client**

Operating Mode: Wireless Client
IP: 130.136.22.49
Netmask: 255.255.255.0
Ethernet Gateway: 130.136.22.50
SSID: “my_wlan1”
wireless channel: 6
WEP encryption: 256 bit mode HEX
WEP Key: 23cd4f3a00be...

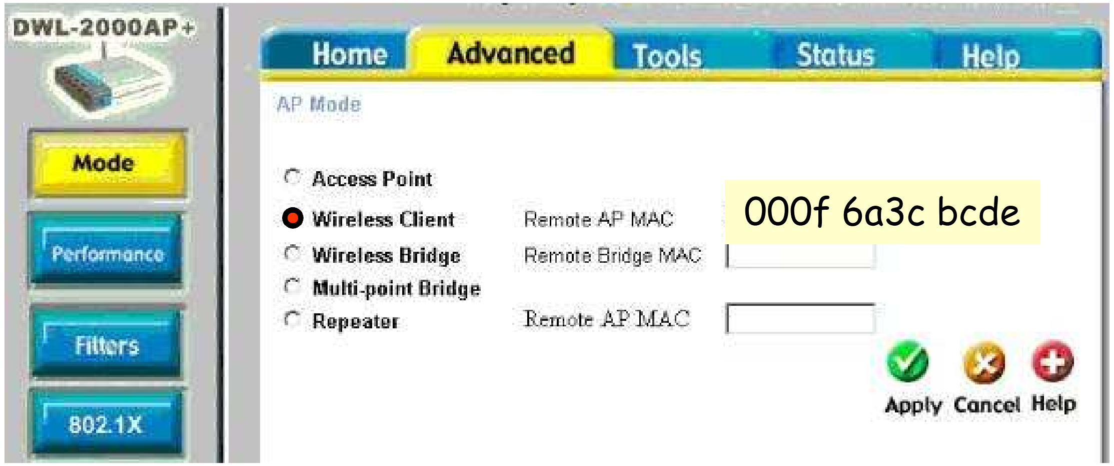


802.11 MAC addr.
000f 6a3c bcde



Ethernet MAC addr.
000f 33dd abcd

130.136.22.host/24



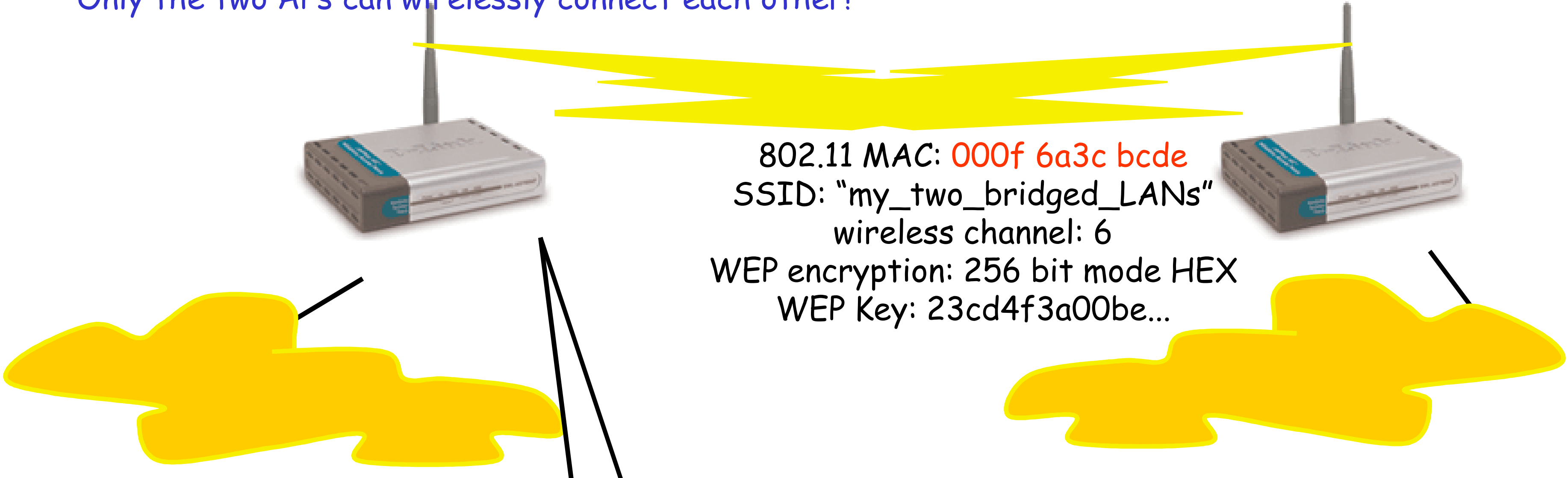
AP Mode

○ Access Point
● Wireless Client — Remote AP MAC: 000f 6a3c bcde
○ Wireless Bridge — Remote Bridge MAC:
○ Multi-point Bridge
○ Repeater — Remote AP MAC:

# Configuration of a Wireless Network

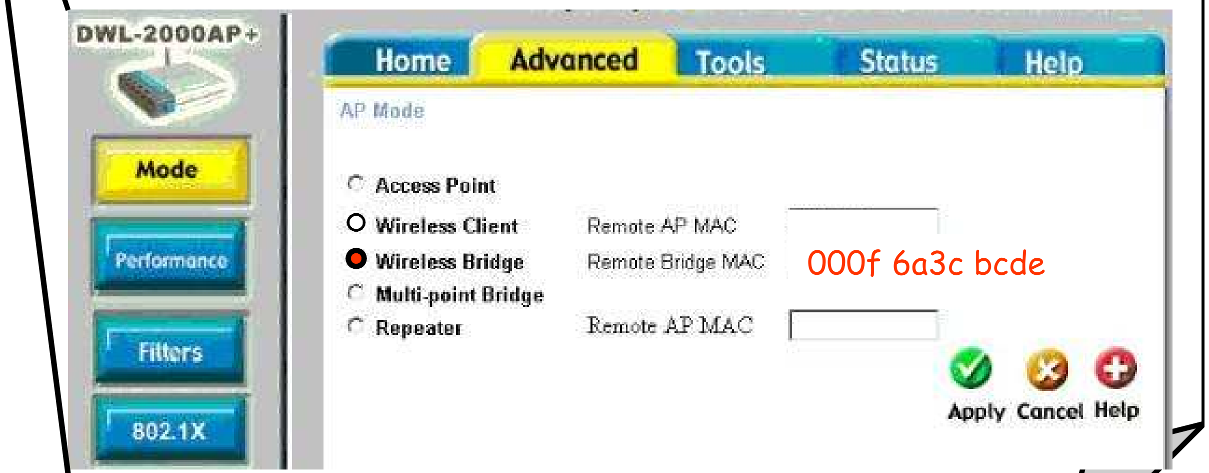
- **Other AP operating modes: Wireless Bridge Mode**

Only the two APs can wirelessly connect each other!



802.11 MAC: 000f 6a3c bcde
SSID: "my_two_bridged_LANs"
wireless channel: 6
WEP encryption: 256 bit mode HEX
WEP Key: 23cd4f3a00be...

Only two APs can connect each other!
SSID: "my_two_bridged_LANs"
wireless channel: 6
WEP encryption: 256 bit mode HEX
WEP Key: 23cd4f3a00be...



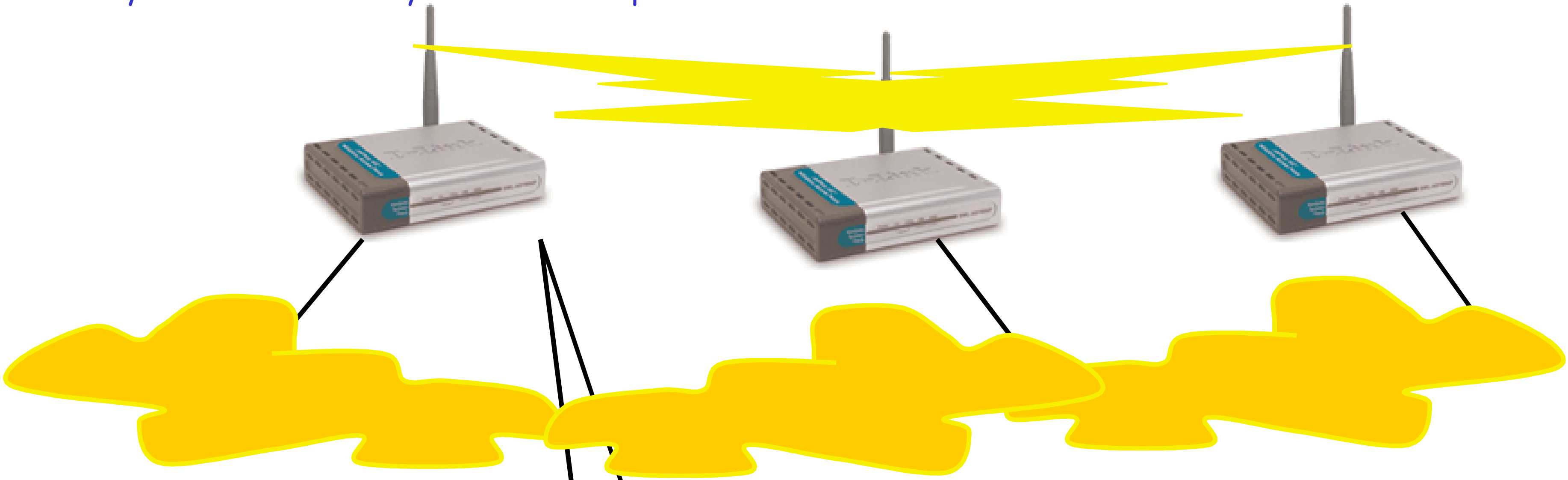
AP Mode

○ Access Point
○ Wireless Client — Remote AP MAC
● Wireless Bridge — Remote Bridge MAC: 000f 6a3c bcde
○ Multi-point Bridge
○ Repeater — Remote AP MAC

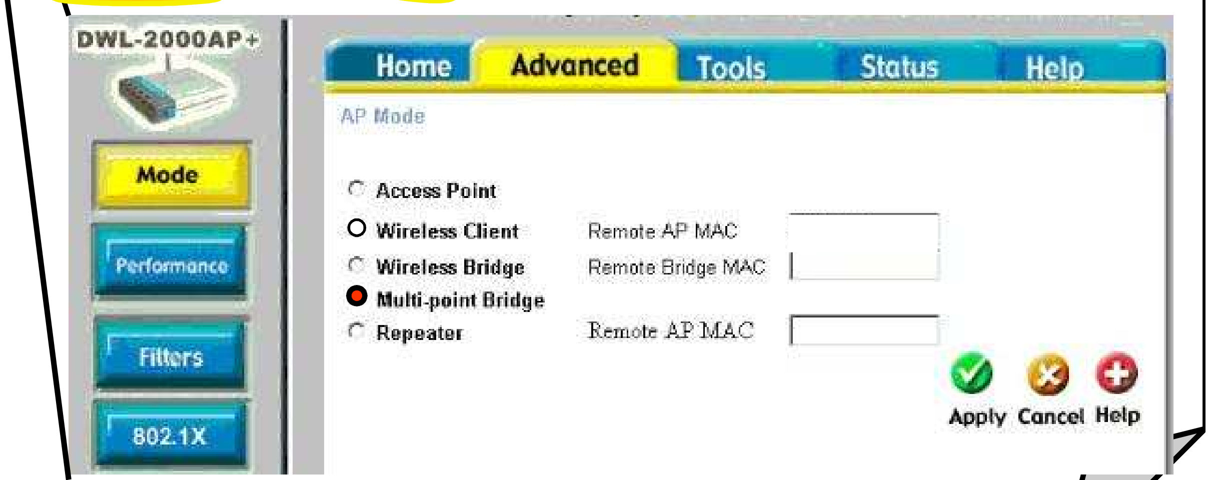
# Configuration of a Wireless Network

- **Other AP operating modes: Multi-point Wireless Bridge Mode**

  *Many APs can wirelessly connect multiple LANs each other!*



Only two APs can connect each other!
SSID: "my_bridged_LANs"
WEP encryption: 256 bit mode HEX
WEP Key: 23cd4f3a00be...



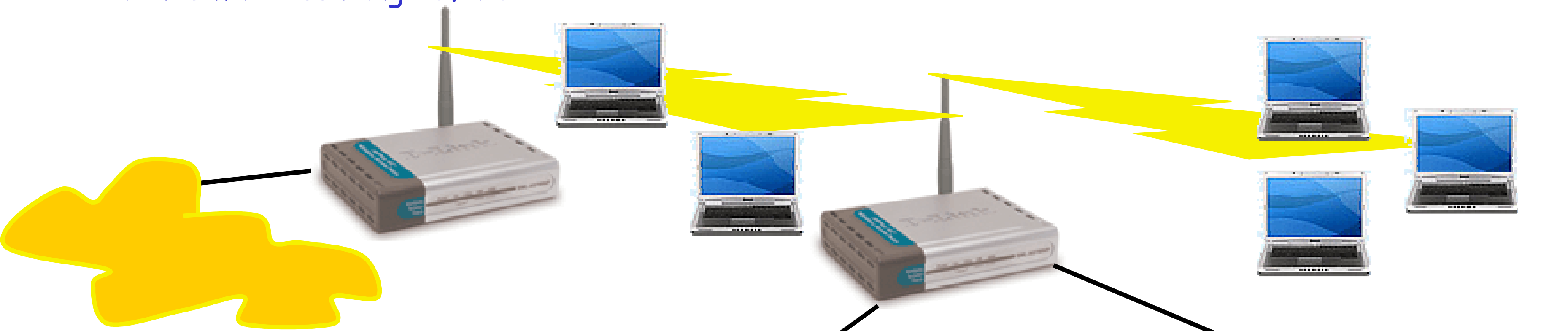
AP Mode

- ○ Access Point
- ○ Wireless Client — Remote AP MAC
- ○ Wireless Bridge — Remote Bridge MAC
- ● Multi-point Bridge
- ○ Repeater — Remote AP MAC

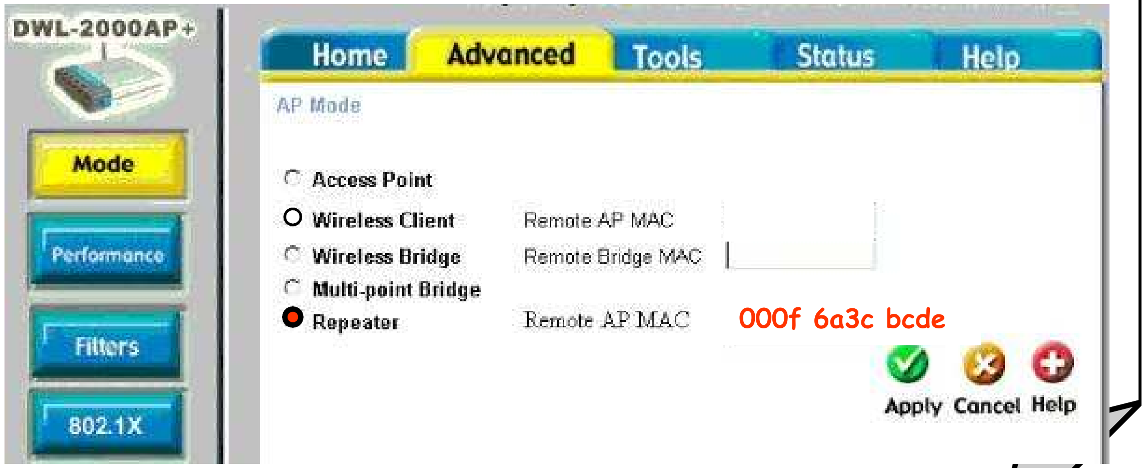
# Configuration of a Wireless Network

- ## Other AP operating modes: Repeater Mode

  extends wireless range of the AP



Operating Mode: Access Point
802.11 MAC addr: 000f 6a3c bcde
IP: 130.136.22.50
Netmask: 255.255.255.0
SSID: "my_wlan1"
wireless channel: 6
WEP encryption: 256 bit mode HEX
WEP Key: 23cd4f3a00be...



AP Mode

○ Access Point

○ Wireless Client Remote AP MAC

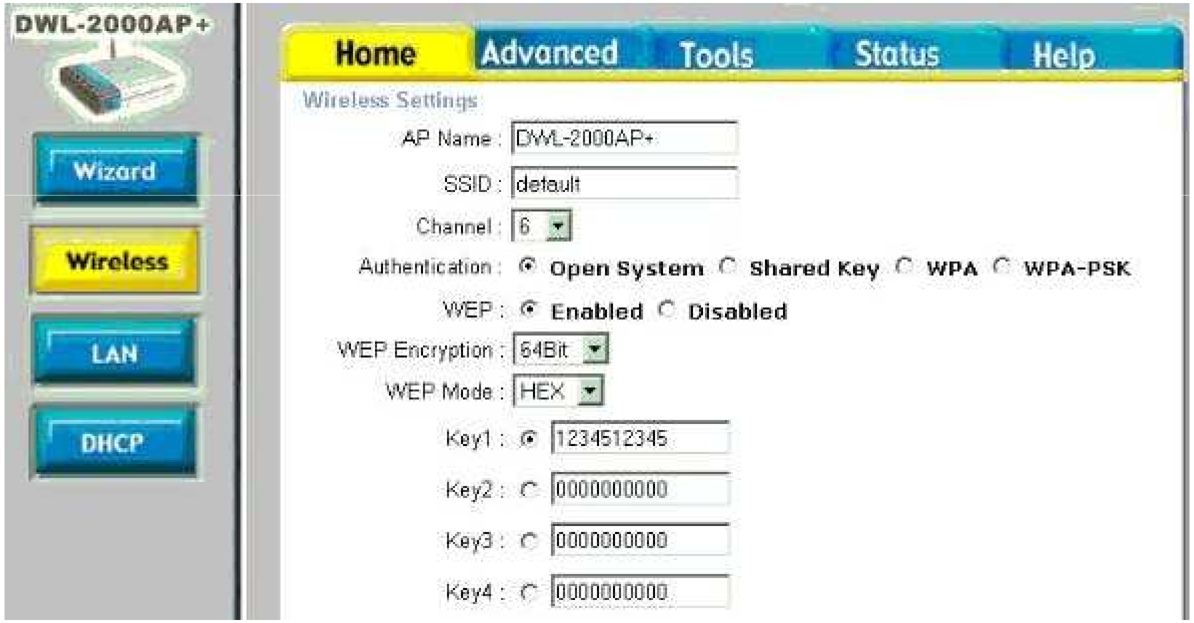
○ Wireless Bridge Remote Bridge MAC

○ Multi-point Bridge

● Repeater Remote AP MAC 000f 6a3c bcde

# Configuration of a Wireless Network

- **Typical AP config. Mask: general configuration parameters**



Wireless Settings

AP Name : DWL-2000AP+

SSID : default

Channel : 6

Authentication : ● Open System ○ Shared Key ○ WPA ○ WPA-PSK

WEP : ● Enabled ○ Disabled

WEP Encryption : 64Bit

WEP Mode : HEX

Key1 : ● 1234512345

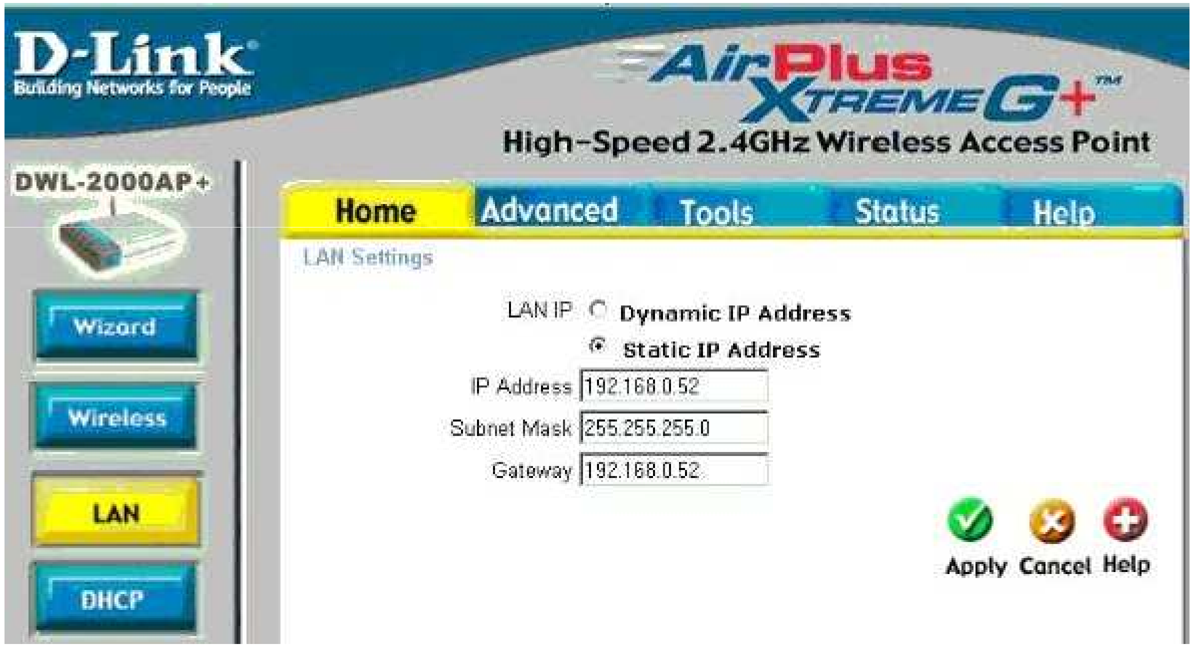
Key2 : ○ 0000000000

Key3 : ○ 0000000000

Key4 : ○ 0000000000

# Configuration of a Wireless Network

- Typical AP config. Mask: LAN IP address



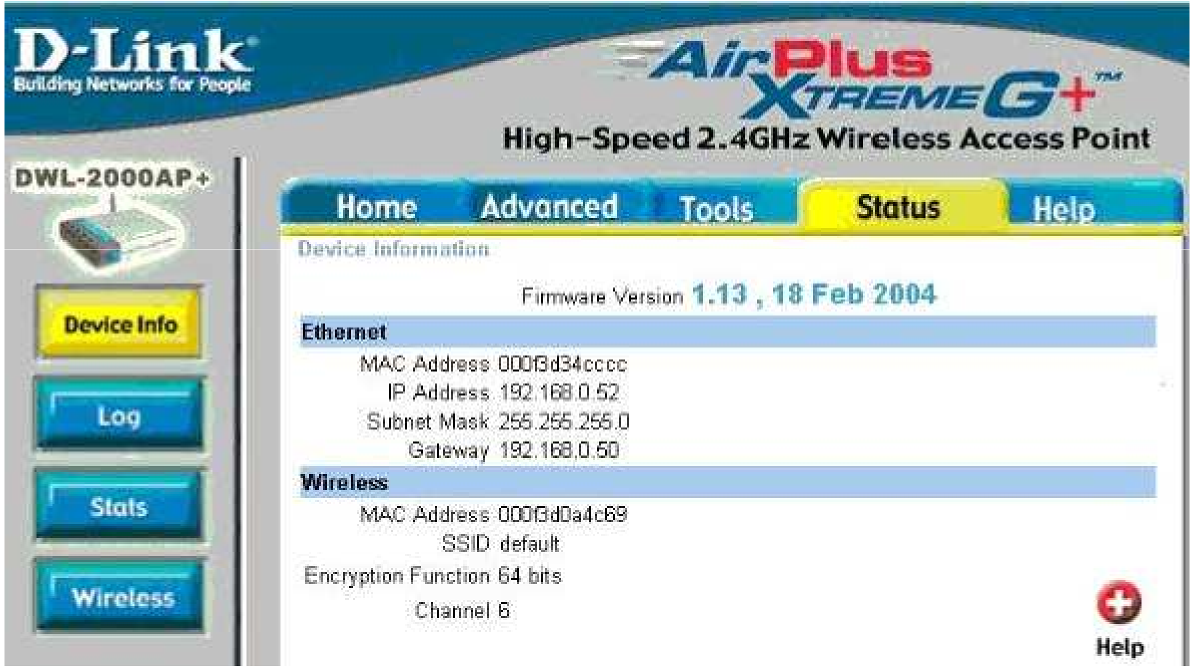
LAN Settings

LAN IP ○ Dynamic IP Address
● Static IP Address

IP Address 192.168.0.52
Subnet Mask 255.255.255.0
Gateway 192.168.0.52

# Configuration of a Wireless Network

- **Typical AP config. Mask: (example, wireless client)**



Device Information

Firmware Version 1.13 , 18 Feb 2004

**Ethernet**

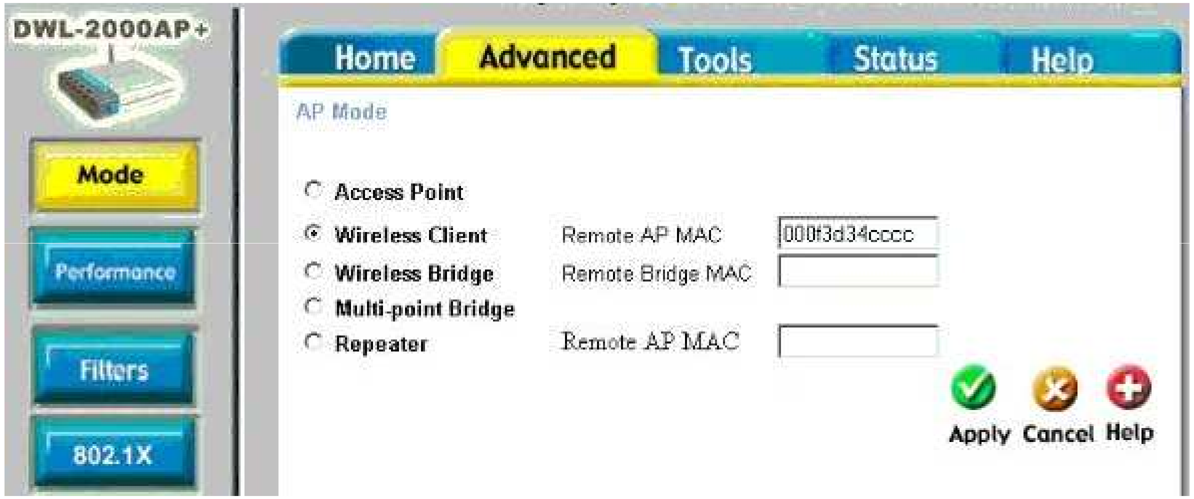
MAC Address 000f3d34cccc
IP Address 192.168.0.52
Subnet Mask 255.255.255.0
Gateway 192.168,0.50

**Wireless**

MAC Address 000f3d0a4c69
SSID default
Encryption Function 64 bits
Channel 6

# Configuration of a Wireless Network

- **Typical AP config. Mask: set AP operating mode**



AP Mode

○ Access Point

● Wireless Client — Remote AP MAC: 000f3d34cccc

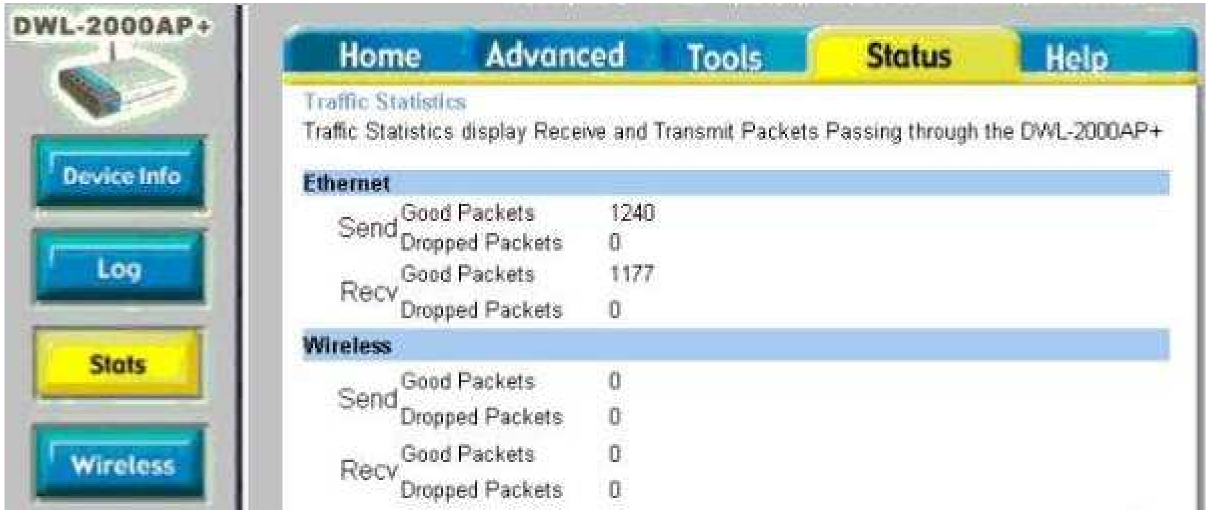
○ Wireless Bridge — Remote Bridge MAC:

○ Multi-point Bridge

○ Repeater — Remote AP MAC:

# Configuration of a Wireless Network

- Typical AP config. Mask: check MAC layer connection



Traffic Statistics

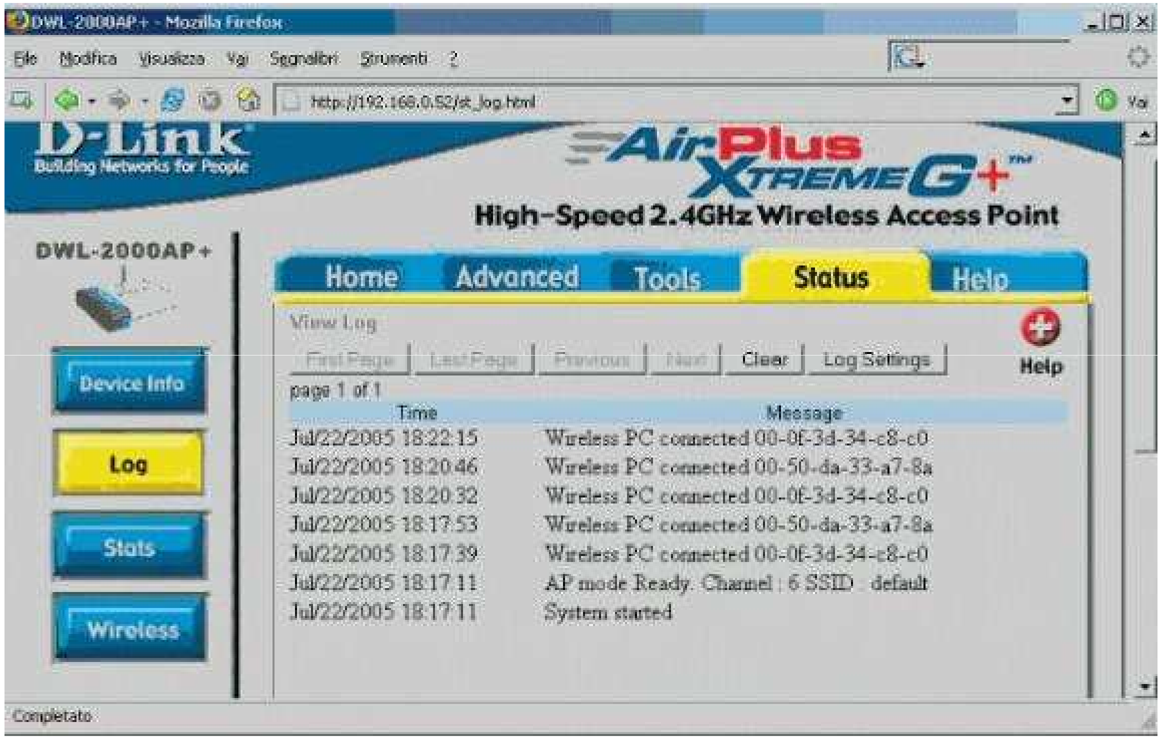
Traffic Statistics display Receive and Transmit Packets Passing through the DWL-2000AP+

| Ethernet | | |
|---|---|---|
| Send | Good Packets | 1240 |
| | Dropped Packets | 0 |
| Recv | Good Packets | 1177 |
| | Dropped Packets | 0 |

| Wireless | | |
|---|---|---|
| Send | Good Packets | 0 |
| | Dropped Packets | 0 |
| Recv | Good Packets | 0 |
| | Dropped Packets | 0 |

# Configuration of a Wireless Network

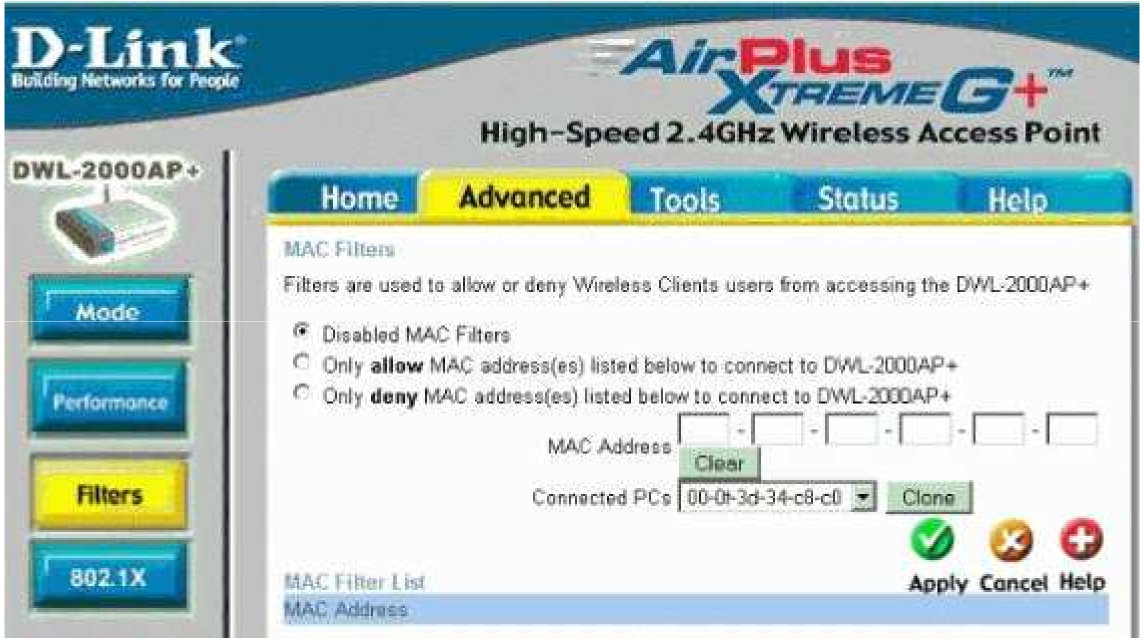
- **Typical AP config. Mask: log connection status of AP**


DWL-2000AP+ - Mozilla Firefox
File Modifica Visualizza Vai Segnalibri Strumenti ?
http://192.168.0.52/st_log.html
Vai
D-Link
Building Networks for People
AirPlus XTREME G+™
High-Speed 2.4GHz Wireless Access Point
DWL-2000AP+
Home
Advanced
Tools
Status
Help
Device Info
Log
Stats
Wireless
View Log
First Page
Last Page
Previous
Next
Clear
Log Settings
Help
Completato

```
page 1 of 1
         Time                          Message
Jul/22/2005 18:22:15     Wireless PC connected 00-0f-3d-34-c8-c0
Jul/22/2005 18:20:46     Wireless PC connected 00-50-da-33-a7-8a
Jul/22/2005 18:20:32     Wireless PC connected 00-0f-3d-34-c8-c0
Jul/22/2005 18:17:53     Wireless PC connected 00-50-da-33-a7-8a
Jul/22/2005 18:17:39     Wireless PC connected 00-0f-3d-34-c8-c0
Jul/22/2005 18:17:11     AP mode Ready. Channel : 6 SSID : default
Jul/22/2005 18:17:11     System started
```

# Configuration of a Wireless Network

- **Typical AP config. Mask: MAC filtering**



MAC Filters

Filters are used to allow or deny Wireless Clients users from accessing the DWL-2000AP+

● Disabled MAC Filters
○ Only **allow** MAC address(es) listed below to connect to DWL-2000AP+
○ Only **deny** MAC address(es) listed below to connect to DWL-2000AP+

MAC Address □ - □ - □ - □ - □ - □
Clear

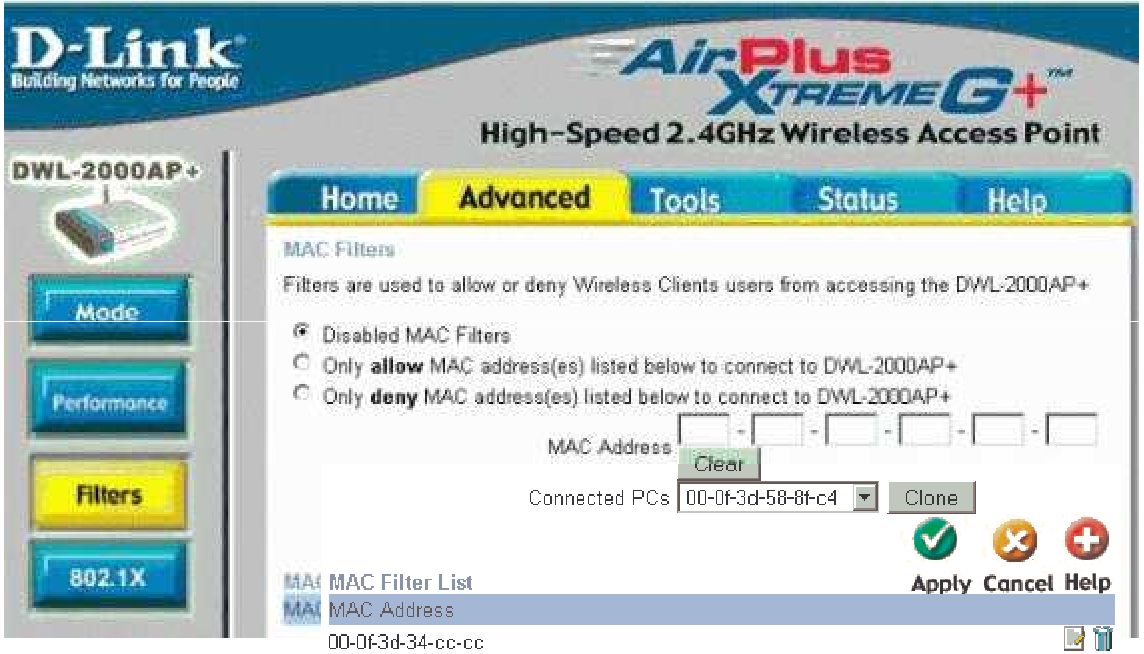
Connected PCs 00-0f-3d-34-c8-c0 ▾ Clone

MAC Filter List

MAC Address

# Configuration of a Wireless Network

- **Typical AP config. Mask: MAC filtering**



MAC Filters

Filters are used to allow or deny Wireless Clients users from accessing the DWL-2000AP+

● Disabled MAC Filters

○ Only **allow** MAC address(es) listed below to connect to DWL-2000AP+

○ Only **deny** MAC address(es) listed below to connect to DWL-2000AP+

MAC Address □ - □ - □ - □ - □ - □ Clear

Connected PCs 00-0f-3d-58-8f-c4 Clone

MAC Filter List

| MAC Address |
|---|
| 00-0f-3d-34-cc-cc |